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Battelle

August 10, 1973

NASA Johnson Space Center
Principal Investigation
   Management Office
Houston, Texas 77058

Attention Mr. Zack H. Byrns, Code TF6

Dear Mr. Byrns:

<div align="center">

Fifth Progress Report
Calibration and Evaluation of Skylab Altimetry
for Geodetic Determination of the Geoid (Contract NAS9-13276)
July 1 to July 31, 1973

</div>

PROGRESS

During this period, we completed the process of simulation of data and validation
of the computer program required in the reduction and analysis for calibration
and evaluation of the S-193 Skylab Altimeter range data. We have also performed
limited error analysis to establish the performance criteria. The scope of this
analysis was curtailed because we limited the weighting criteria analysis which
cannot be realistically completed in the absence of real data. A brief Summary
of the simulation and analysis investigation is attached as an Appendix. We are
extremely satisfied with the results obtained. We received and reviewed the
following documents:

(1) SL-2 EREP Summary Report, PIMO, July, 1973;

(2) SL-3 Mission Supplement to the Skylab EREP Field
     Data Pack, July 30, 1973;

(3) 4 microfiches on reports we previously requested;

(4) Copy of a report on "SKYBET Parameter Formulation
     Document", Change 1, February 8, 1973. (This was
     sent to us by Mr. Jiongo of the Data Processing
     Branch).

PROBLEMS

The two main problems encountered in this period are associated with (1) SKYBET
data used in the simulation investigations, as discussed in the Appendix; and (2)
the delay in the receipt of Skylab data.

RECOMMENDATIONS

None at this time.

NEXT PERIOD

During the next period, we expect to (1) check the reports we received and resolve the problem of the transformation of time-dependent coordinate system of SKYBET data; (2) concentrate on ground truth geoidal analysis required for calibration and validation and (3) initiate the development of a program to handle the data from subsequent Skylab missions using sequential update solution technique to economize both computer time and storage requirements.

TRAVEL

The principal investigator may attend the GEOP Conference on the Geoid and Ocean Surface Topography to be held in Boulder, Colorado on August 16-18, 1973, under a separate NASA Contract.
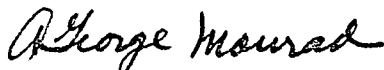
RESULTS

See Appendix.

SUMMARY OUTLINE

The delay in receipt of the altimeter range data and the discovery of unanticipated problems in the use of SKYBET data have perturbed the schedule in our milestone plan. We hope that these are temporary.

Very truly yours,

A. George Mourad

A. George Mourad
Principal Investigator
Project Manager, Geodesy & Ocean Physics
Transportation and Space Systems Department

AGM:eab

Enc.

cc: Mr. V. M. Dauphin, Mail Code TF, NASA-JSC, Houston, Texas (1)
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APPENDIX

This Appendix summarizes the Validation and Simulation
Investigations and the problems encountered in the use of SKYBET data.

Validation and Simulation Investigations

The first phase of the formulation for analytical data
handling has been completed. Details of this formulation will be
submitted later. The main features of the formulations include:

(1) The condition equation of intrinsic parameters. This
expresses mathematically the functional relationships of the orbital
parameters, the altimeter range data with associated calibration
constant(s) (to be deduced) and related residual errors, sea state
measurement biases, geodetic ground truth, geoidal heights (to be
derermined) and parameters of the reference ellipsoid;

(2) The generalized least squares and sequential adjustment
model for the data processing;

(3) Statistical establishment of confidence in numerical
processing and the derived results.

Skylab altimetry is a first in history. Consequently,
these formulations have never been used before. It was therefore,
necessary to validate the formulations and the computer coding using
simulated altimeter ranges, actual orbital ephemeris from the SKYBET
data and geoidal control information along the subsatellite flight path.

The x, y, z ECT coordinates of the satellite, taken from
SKYBET, were used to simulate the ranges. Random errors with
preassigned standard deviations were generated with subroutine GAUSS
and added to the simulated altimeter ranges. A constant bias simulating
the altimeter calibration factor and bias in the sea state measurement
were added to each simulated range. Based on all these factors and error
propagation techniques, the weighting function for each of the parameters
was deduced for the boundary conditions in the generalized least squares
solution.

All this information (as it will be with the real data) was processed by computer, using the analytical formulations derived for the geodetic calibration and evaluation of Skylab Altimetry for determination of the geoid. The results were entirely satisfactory. For instance, in each test, the recovered altimeter bias or calibration constant differed from the actual simulated constant by less than 0.3 meters. However, the accuracy of this recovery is highly dependent on (1) the use of at least 2 geodetic (geoidal) ground control points for each set of Skylab data of about 15 to 25 minutes duration, and (2) the assumption of constancy in magnitude and sign of orbital errors during this 15 to 25 minutes period or any other suitable time interval chosen. This is one of the reasons why, as we had anticipated, we did recommend in a previous status report, that all available ground tracking stations within range, should track the Skylab whenever the altimeter is on.

Problems With SKYBET Data

As part of the investigation, each x, y, z ECT coordinates from SKYBET must be converted into geodetic latitude, longitude and height of the satellite above the reference ellipsoid. The conversion to the longitude, λ, which is the simplest of the three operations presented a big puzzle. When checked against values computed at JSC, Houston, there was a constant difference of several degrees that also varied with time at about 0.25 deg/minute of time. For instance, for EREP PASS No. 6, GT 19, and starting from GMT 160: 15: 07: 00 (Zulu date) to GMT 160: 15: 31: 00, the discrepancy varied from 25.069 to 31.085 degrees. Following our contact with the contract monitor, Mr. Z. Byrns and Mr. Jiongo of JSC, we have just received the NASA documentation explaining the source and computational remedy for the discrepancy. We plan to implement the instructions in the documentation and hope that the problem be resolved.

Some of the print-outs of SKYBET are difficult to read and depend on intelligent guesses. We recommend that this problem be addressed at JSC before sending us the real data.